

## CLAIMS

We claim:

1. A radio receiver comprising:

a receive signal path including:

a filter;

a pre-filter section prior to the filter, the pre-filter section including at least one adjustable gain element to provide an adjustable gain to the pre-filter section; and

at least one post-filter section after to the filter, the post-filter section including at least one adjustable gain element to provide an adjustable gain to the post-filter section;

a pre-filter signal strength detector coupled to the pre-filter section to measure the relative strength of the signal at a point in the receive signal path prior to filtering by the filter;

a post-filter signal strength detector coupled to the pre-filter section to provide a measure of the relative strength of the signal at a point in the receive signal path after filtering by the filter; and

an automatic gain controller (AGC controller) coupled to the pre-filter and post-filter signal strength detectors and further coupled to the variable gain elements to set the gains of the respective sections according to the pre-filter and post-filter signal strength measures, the gains setting providing an overall gain setting for the receive path,

such that the gain settings of the pre-filter and post filter variable gain elements adapt according to the signal characteristics, and take into account the amount of filtering provided by the filter.

2. A receiver as recited in claim 1, wherein the ACG controller corrects and averages each of the pre-filter and post-filter signal strength indications, compares the pre-filter and post-filter corrected averaged signal strength indications to respective pre-filter and post-filter desired signal powers, and adjusts the gains of the respective sections to reduce the differences between the corrected averaged indications and desired signal powers.
3. A receiver as recited in claim 2, wherein the correction of the pre-filter and post-filter signal strength indications is to bring the indications to a common scale so that the indications may be compared, and wherein the adjusting of the gains of at least one of the sections depends on both the pre-filter and post-filter corrected and averaged signal strength indications.
4. A receiver as recited in claim 2, wherein the ACG controller operates in sequential stages, each stage setting the gains of one of more sections.
5. A receiver as recited in claim 4, wherein a first stage sets the gain of the pre-filter section according to the pre-filter signal strength indications, and other stages finalize the gain setting of the post-filter sections, section by section according to additional signal strength indications from the relevant sections.
6. A receiver as recited in claim 1, wherein the receive signal path includes an RF section operating at RF and an intermediate frequency (IF) section after the RF section operating at an intermediate frequency, and wherein the filter is in the intermediate frequency section of the receive signal path.
7. A receiver as recited in claim 1, wherein the receiver uses a direct conversion architecture such that the receive signal path includes an RF section operating at RF and direct downconversion from the RF section to a baseband section operating at baseband, and wherein the filter is in the baseband section, such that the one or more post-filter sections are in the baseband section.
8. A receiver as recited in claim 1, wherein the AGC controller is a digital controller, the receiver further includes one or more analog-to-digital converters to convert the pre-filter and post-filter signal strength indications to digital signals for input to the AGC controller.

9. A receiver as recited in claim 6, wherein the receive signal path further comprises:
  - an analog to digital converter to convert the output of the last analog component in the receiver signal path to a digital output signal;
  - wherein there are two or more post filter sections including a first post filter section and a second post filter section, the second post signal section including the analog to digital converter,
  - wherein the post-filter signal strength detector is coupled to the first pre-filter section;
  - wherein the digital signals from the ADC provide a measure of the signal strength post-digitization digitization to the AGC controller; and
  - wherein the AGC controller is to set the gains of the pre-filter section, the first post-filter section, and the second post filter section according to the pre-filter and post-filter signal strength measures and the post-digitization signal strength measure.
10. A receiver as recited in claim 6, wherein the signal path includes a second filter between any variable gain element in the first post-filter section and any variable gain element in the second post-filter section, such that the gain setting takes into account the amount of filtering by the second filter in addition to the amount of filtering by the first filter.
11. A method for controlling the gain of a radio receiver, the receiver having a receive signal path including
  - a filter;
  - a pre-filter section prior to the filter, the pre-filter section including at least one adjustable gain element to provide an adjustable gain to the pre-filter section; and
  - at least one post-filter section after to the filter, the post-filter section including at least one adjustable gain element to provide an adjustable gain to the post-filter section;
 the method comprising:

accepting a measure of the pre-filter signal strength at a point in the receive signal path prior to filtering by the filter;

accepting a measure of the post-filter signal strength at a point in the receive signal path after the filtering by the filter;

setting the gains of the respective sections according to the pre-filter and post-filter signal strength measures, the gain setting providing an overall gain setting for the receive path,

such that the gain settings of the pre-filter and post filter variable gain elements adapt according to the signal characteristics, and take into account for the amount of filtering provided by the filter.

12. A method as recited in claim 11, wherein the accepting of the measures includes calibrating the pre and post-filter signal strength measures so that they may be compared.
13. A method as recited in claim 11, wherein the accepting of the measures averaging each of the pre-filter and post-filter signal strength measures, and wherein the setting of the gains includes comparing the pre-filter and post-filter corrected averaged signal strength measures to respective pre-filter and post-filter desired signal powers, and adjusting the gains of the respective sections to reduce the differences between the corrected averaged measures and the respective desired signal powers.
14. A method as recited in claim 13, wherein the setting of the gains of at least one of the sections depends on both the pre-filter and post-filter corrected averaged signal strength measures to account for the amount of filtering provided by the filter.
15. A method for controlling the gain of a radio receiver for receiving packets of information, the receiver connected to an antenna subsystem, the receiver's receive signal path including a plurality of sections including a first section coupled to the antenna subsystem and a next section, each section having an adjustable gain, each section able to provide a measure of the signal strength at its output; the method comprising:

waiting for a start of packet indication;

providing measures of the signal strengths at the outputs of the first and the next sections; and

adjusting the gains of the first and the next sections using the provided measures of signal strength.

16. A method as recited in claim 15, further comprising setting the gains of the sections to a default level prior to waiting for a start of packet indication.

17. A method as recited in claim 15,

wherein the receiver includes a filter in the receive signal path, the providing a measure of the signal strength at the output of the first section being at a point before the filter, and the providing a measure of the signal strength at the output of the next section being at a point after the filtering, the method further comprising:

correcting the provided measures of signal strength at the at the outputs of the first section and next section to determine measures on a common scale such that the corrected measures may be compared,

wherein the gain adjusting adjusts at least one of the first or next section's gain according to both the provided measure of signal strength at the output of the first section and at the output of the first section.

18. A method as recited in claim 15, wherein gain adjusting of the sections is carried out sequentially in respective AGC stages, each stage adjusting the gain of one or more corresponding sections, each stage including:

providing a measure of the signal strengths at the ends of the corresponding sections; and

comparing the provided measures of signals strength at the ends of the corresponding sections to a desired signal strength level for each corresponding section; and

adjusting the gain of the corresponding sections according to the respective differences between the desired levels and the provided measures of signal strength for the respective corresponding sections.

19. A method as recited in claim 18, wherein the providing the measures of the signal strengths at the ends of the sections includes calibrating so that the measures may be compared.
20. A method as recited in claim 19,  
  
wherein the receiver includes a filter in the receive signal path, the providing a measure of the signal strength at the output of the first section being at a point before the filter, and the providing a measure of the signal strength at the output of the next section being at a point after the filtering, and  
  
wherein the desired level of at least one of the sections depends on both the provided measure of signal strength at the output of the first section and at the output of the next section such that the gain adjusting accounts for the amount of filtering by the filter.
21. A method as recited in claim 18, wherein each gain adjusting stage finalizes the gain of one corresponding section, such that the providing the signal strength measure and the adjusting of the first section's gain is carried out during a first AGC stage, the finalizing of the adjusting of the second section's gain is carrier out during a second AGC stage, respectively, and wherein the method comprises for each stage and corresponding section:  
  
providing a measure of the signal strengths at the end of the sections; and  
  
comparing the provided measure of signal strength at the end of the corresponding section to a desired signal strength level for the corresponding section; and  
  
adjusting the gain of the corresponding section according to the difference between the desired level and the provided measure of signal strength for the corresponding section.

22. A method as recited in claim 18, wherein the radio is for operation in a wireless network conforming to the IEEE 802.11 standard.
23. A method as recited in claim 18, wherein the ACG controller takes approximately 1 to 2  $\mu$ s for each AGC stage.
24. A method as recited in claim 18,  
wherein the receiver is a superheterodyne receiver that includes in its receive signal path a first downconverter to convert a received signal at RF to an IF signal, a second downconverter to convert the IF signal to baseband, and a filter at IF between the first and second downconverters, the receive signal part further including a filter in the IF part,  
wherein the receive signal path is including a pre-filter section before the filter, a post filter section after the filter, and a third section after the post-filter section,  
wherein the plurality of AGC stages includes three stages, the first stage including setting the gain of the pre-filter section, the second stage including setting the gain of the post-filter section, and the third stage including setting the gain of the third section.
25. A method as recited in claim 24,  
wherein the providing of the measure of signal strength for the pre-filter and post-filter stages includes for each stage providing a measure of the respective signal strength in a logarithmic scale, converting the respective measured signal strength to digital signal strength samples, correcting and averaging a respective set of the digital signal strength samples to produce pre-filter and post-filter signal strength measurements, respectively, to compare to the desired values in the respective comparing steps, and  
wherein the providing the measure of signal strength for the third stage includes providing a baseband output of the third section, converting the baseband output of the third section to digital samples, converting the digital samples to digital signal strength samples in a logarithmic scale, correcting and averaging a set of the logarithmic-scale digital signal strength samples to produce a third signal strength measurement to compare to the desired value in the comparing step of the third stage.

26. A method as recited in claim 18, wherein the receiver is coupled to a two antennas via a diversity switch; the method further comprising in one of the AGC stages selecting the antenna to use according to at least one of the provided measurements of signal strength.
27. A method as recited in claim 26, wherein the determining of which antenna to use is carried out only for weak signals and replaces the first AGC stage.
28. A method as recited in claim 18,  
wherein at each stage,  
  
the comparison for each section determines a respective setpoint error, and  
  
the adjusting of each section includes determining a requested gain as the existing gain, produced by the current gain setting, minus the setpoint error from the respective comparison step, the adjusting including mapping the existing gain minus the setpoint error to a respective gain setting.
29. A method as recited in claim 28,  
  
wherein the result of providing a measure of signal strength for at least one of the sections section is used to update the gain settings for multiple selected sections of the receive path.
30. An AGC controller to control the gain of a radio receiver for receiving packets of information, the receiver including:  
  
a receive signal path including a plurality of sections, each section having an adjustable gain, the plurality of sections including a first section coupled to the antenna subsystem and a next section; and  
  
a signal strength measurer coupled to each section to provide a measure of the signal strength at the section's output;  
  
the AGC controller being configured to:  
  
wait for a start of packet indication; and



accept measures of the signal strengths from the signal strength measurers at the outputs of the first and next sections; and

adjust the gains of the first and the next sections using the accepted measures of signal strengths.

31. An AGC controller as recited in claim 30, wherein the receiver includes a filter in the receive signal path, the signal strength measurer of the first section provides a measure of the signal strength at a point before the filter, and the signal strength measurer of the next section provides a measure of the signal strength at a point after the filter, such that the gain adjusting sets the first section's gain according to the accepted measure of signal strength at the output of the first section and sets the next section's gain according to the accepted measure of signal strength at the output of the next section relative to the accepted measure of signal strength at the output of the first section.

32. An AGC controller as recited in claim 30, wherein the gain adjusting of the sections is carried out sequentially in respective AGC stages, each stage corresponding to and adjusting the gains of one or more corresponding sections, such that the ACG controller is configured to, after the start of packet indication, carry out a plurality of sequential AGC stages, each stage having one or more corresponding section, carrying out a stage including for each stage and corresponding sections:

accepting a measure of the signal strength at the end of the corresponding sections;

comparing the measured signal strength at the end of the corresponding sections corresponding to respective desired levels for the respective corresponding sections; and

adjusting the gains of the corresponding sections according to the respective differences between the respective desired level and the respective measured signal strengths for the respective corresponding sections.

33. An AGC controller as recited in claim 32,

wherein the receiver is a superheterodyne receiver that includes in its receive signal path a first downconverter to convert a received signal at RF to an IF signal, a second downconverter to convert the IF signal to baseband, and a filter at IF between the first and second downconverters, the receive signal part further including a filter in the IF part,

wherein the receive signal path is including a pre-filter section before the filter, a post filter section after the filter, and a third section after the post-filter section,

wherein the plurality of AGC stages includes three stages, the first stage including setting the gain of the pre-filter section, the second stage including setting the gain of the post-filter section, and the third stage including setting the gain of the third section.

34. An AGC controller as recited in claim 32,

wherein for each stage:

the comparisons of each of the corresponding sections determine respective setpoint errors for each of the corresponding sections, and

the adjusting of each respective corresponding section determines a requested gain as the existing gain, produced by the current gain setting, minus the setpoint error from the respective comparison step, the adjusting including mapping the existing gain minus the setpoint error to a respective gain setting.

35. An AGC controller as recited in claim 34,

wherein the result of each section's measuring is used to update the gain settings for multiple selected sections of the receive path.

36. An AGC controller as recited in claim 34, comprising a finite state machine configured to carry out the waiting and AGC stages.

37. An AGC controller as recited in claim 34, comprising a processing system programmed to carry out the waiting and AGC stages.

38. An apparatus for controlling the gain of a radio receiver for receiving packets of information, the receiver including:

a receive signal path including a plurality of sections, each section including means to control the section's gain; and

means for measuring a measure of the signal strength at the section's output;

the apparatus comprising:

means for waiting for a start of packet indication; and

means for carrying out a plurality of AGC stages, each stage corresponding to one or more sections, the means for carrying out an AGC stage including for each stage and corresponding sections:

means for receiving measures of the signal strengths at the end of the corresponding sections;

means for comparing the measured signal strengths at the ends of the corresponding sections to respective desired signal strength levels for the respective corresponding sections; and

means for adjusting the gains of the corresponding s according to the differences between the respective desired levels and the respective measured signal strengths for the corresponding sections.

39. An apparatus as recited in claim 38, wherein the receiver includes a filter in the receive signal path, the means for measuring at the end of the first section being at a point before the filter, and the means for measuring at the end of the second section being at a point after the filtering.

40. A carrier medium carrying one or more computer readable code segments to instruct one or more processors of a processing system to carry out a method for controlling the gain of a radio receiver for receiving packets of information, the receiver's receive signal path being including a plurality of sections, each section having an adjustable gain, each section providing a measure of the signal strength at its output; the method comprising:

waiting for a start of packet indication; and

carrying out a plurality of AGC stages, each stage corresponding to one or more sections, including for each stage and corresponding sections:

measuring the signal strengths at the ends of the corresponding sections;

comparing the measured signal strengths at the ends of the corresponding sections to a respective desired signal strength levels for the corresponding sections; and

adjusting the gains of the corresponding sections according to the differences between the respective desired levels and the respective measured signal strengths for the corresponding sections.

41. A method as recited in claim 40, wherein the receiver includes a filter in the receive signal path, the measuring at the first stage being at a point before the filter, and the measuring at the second AGC stage being at a point after the filtering.